Static Magnetic Moment In Thin Cu Layers Exchange Coupled To Co Imaged By XPEEM.

H. Ohldag[1,2,3], A. Scholl[1], F. Nolting[1,2] and J. Stöhr[2]
[1]Advanced Light Source, Ernest Orlando Lawrence Berkeley National Laboratory, University of California, Berkeley, California 94720, USA
[2]Stanford Synchrotron Radiation Laboratory, P.O. Box 20450, Stanford CA 94309, USA
[3]Institute of Applied Physics, Universität Düsseldorf, 40225 Düsseldorf, Germany

Future magnetic devices will be based on spin injection structures, where a spin polarized current is driven by an external voltage from a ferromagnet into a non ferromagnet. A model system for such a structure is Co/Cu. Due to the ferromagnetism of cobalt the electron density at the Fermi level, that is relevant for transport processes like electric current, is spin polarized. If now such a current penetrates a non-ferromagnet like copper it is expected that a dynamic magnetization process will occur, that causes a ferromagnetic spin polarization in Cu in an interface near region proportional to the current density across the interface. It is estimated that the dynamic magnetic moment induced into the Cu is of the order of a 10^{-3} μB.

In a first step we address the question whether we are able to see the small static magnetic moment induced into Cu across the Co/Cu interface by exchange coupling that is of the order of a few of 10^{-2} μB. We image the domain structure using x-ray magnetic circular dichroism [1] in a photoemission electron microscope. Three monolayers (0.5nm) of Cu were deposited by molecular beam epitaxy onto a demagnetized thin Co film that splits up into large ferromagnetic domains. The thickness of the Cu layer is chosen such that it is thick enough to give a reasonable x-ray absorption signal and thin enough so that the interface region contributes with a large portion to the signal.

The result is shown in figure 1. The Co domain pattern can clearly be seen on the left side. The Cu pattern on the right side is very weak and therefore exhibits a lot of noise and residual topographic signal but nevertheless the complete replica of the Co pattern can be recognized. We compared the contrast between the two layers and found that the contrast in Cu is about two orders of magnitude smaller than in Co. With the Co moment known to be 2μB the Cu moment can be estimated to be around $50*10^{-3}$ μB.

We conclude the following. At the present state of the instrument we are able to see the static moment of Cu induced across a Co/Cu interface. However the signal is very small and we reach the limit of the microscope. Because the dynamic moment will be around an order of magnitude smaller than the observed static moment further improvements of the instrument have to be made. A new CCD camera that allows longer exposure times with a smaller signal to noise ratio will be the first step. Future spectroscopy studies to determine the exact size of the dynamic moment will reveal whether the improvements are sufficient or if it remains a question that will be addressed by the new aberration corrected microscope built at the Advanced Light Source.

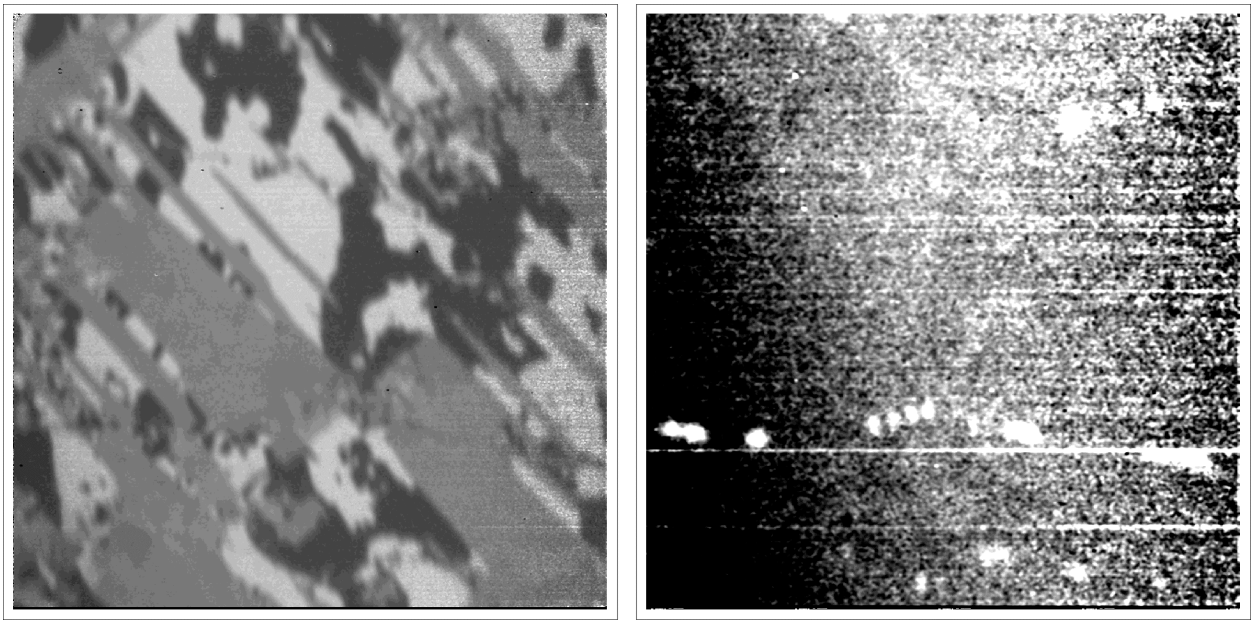

Figure 1. XMCD Images of a ferromagnetic domain pattern in 10 monolayers of Co (left) and in a layer of 3 monolayer of Cu (right) on top. Although the contrast is much weaker in the Cu layer a correlation especially across areas on the sample where the contrast in the Co layer is large between large domains can be seen. The maximal contrast appearing from ferromagnetic domains in the Cu layer is about 0.2% compared to 16% in the Co layer. The static magnetic moment induced into the copper can be estimated to be around 0.02 μB from comparison of the contrast values.

REFERENCES

1. J. Stöhr et al., Journal of Magnetism and Magnetic Materials, 200 (1999), 470

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Principal investigator: J. Stöhr, Stanford Synchrotron Radiation Laboratory. Telephone: 650-927-2570. Email: stohr@slac.stanford.edu.